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TITLE: Perpendicular magnetic recording medium - has cobalt-chromium recording layer on laminate of two soft magnetic layers sepd. by non-magnetic layer

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BASIC-ABSTRACT:
A perpendicular magnetic recording medium consists of a base material (1), a backing (2) comprising an under soft magnetic layer (32), a non-magnetic layer (4) and an upper soft magnetic layer (31), and a perpendicular recording layer (5) made from Co-Cr. The upper soft magnetic layer is thicker than the under soft magnetic layer.

ADVANTAGE - The recording medium has improved output power and high packing density. Typically the soft magnetic layers are made from e.g. Permalloy. The

under soft magnetic layer is e.g. 0.1 micron thick and the upper magnetic layer
is e.g. 0.4 micron. The non-magnetic layer is made from e.g. SiO_2 and is e.g.
0.01 micron thick. The recording layer is made from e.g. 80 wt.% Co and 20
wt.% Cr, and is e.g. 0.15 micron thick.

CHOSEN-DRAWING: Dwg.0/2

DERWENT-CLASS: L03 T03 V02

CPI-CODES: L03-B05G;

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VERTICAL MAGNETIC RECORDING MEDIUM
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1. <u>Title of the Invention</u>: VERTICAL MAGNETIC RECORDING MEDIUM

2. <u>Claim</u>

1. A vertical magnetic recording medium, characterized by the fact that in a vertical magnetic recording medium being constituted by laminating at least one set of a lower soft magnetic layer and a nonmagnetic layer on a nonmagnetic substrate, forming a backing layer by laminating an upper soft magnetic layer on it, and further forming a CoCr vertical recording layer on it, the above-mentioned upper magnetic layer is thicker than the above-mentioned lower soft magnetic layer.

3. <u>Detailed explanation of the invention</u>

(Industrial application field)

The present invention pertains to a vertical magnetic recording medium, and in particular, it pertains to an improvement of its layer structure.

(Prior art)

As a magnetic recording system suitable for a high-density recording, there is a vertical magnetic recording system. In the system, a vertical magnetic recording medium equipped with a

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[1] Numbers in the margin indicate pagination in the foreign text.

vertical recording layer being easily magnetized in the direction approximately perpendicular to the medium film surface (also, for the vertical magnetic recording, for example, see "High-Density Magnetic Recording Using Vertical Magnetization," Toshiichi Iwazaki, Nikkei Electronics, No. 7, pp.100-111, August 1978, Nihon Keizai Shimbun Inc." As the vertical recording layer, a CoCr layer is often used.

Also, a so-called two-layer film medium in which a backing layer is installed between a substrate and a vertical recording layer to improve the reproducing efficiency is also well known. As the backing layer, a soft magnetic layer, for example, FeNi alloy such as permalloy is used (for the two-layer film medium, for example, see "Development Trend of Each Company for Practicality of Vertical Magnetic Recording," Nikkei Electronics, No. 25, pp.141-154, October 1982).

On the other hand, in case the two-layer film medium was applied to magnetic disks, etc., the angle between the easy axial direction of magnetization in the plane of the backing layer (soft magnetic layer) and the running direction of the magnetic head was changed in the same track, so that a so-called modulation in which the reproducing output was varied in the track was caused. Also, the improvement of the permeability of the backing layer, especially a high band has been in demand to /2
obtain a high-density recording.

In order to solve this problem, a two-layer film medium in which the backing layer consists of a soft magnetic layer and a

nonmagnetic layer is well known (for example, see Japanese Kokai Patent Application Nos. Sho 58[1983]-166531, Sho 59[1984]-193529, Sho 60[1985]-140525, etc.).

Next, the two-layer film medium equipped with the laminated backing layer is explained by the figure.

Figure 2 shows a cross section structure of a conventional two-layer film medium. In the figure, 1 is a nonmagnetic substrate, and 2 is a backing layer formed on said nonmagnetic substrate 1 and has a multilayer structure in which a nonmagnetic layer 4 is interposed between two soft magnetic layers 3. 5 is a vertical recording layer formed on the above-mentioned backing layer 2. Here, in order to suppress the generation of modulation by relaxing the bias in the easy axial direction of magnetization in the above-mentioned backing layer 2, if necessary, the easy axis of magnetization of two soft magnetic layers may also be different from each other. However, in this constitution, compared with the backing layer consisting of a soft magnetic monolayer with a thickness equal to the total thickness of the soft magnetic layers, the crystal orientation of the CoCr vertical recording layer on said backing layer 2 was deteriorated (also, for the CoCr crystal orientation, for example, see "High-Speed Formation of CoCr Continuous Medium by Opposite Target Type Sputtering Method," Kume et al., Japanese 27, 1986, CPM 85-112, Technical Research Report of the Telecommunication Society, Vol. 85, No. 237, pp.37-44).

(Problems to be solved by the invention)

Since the conventional magnetic recording medium has the above constitution, the easy axis of magnetization of the CoCr vertical recording layer is not sufficiently aligned perpendicularly to the film surface by the deterioration of the above-mentioned crystal orientation, so that the recording medium is not suitable for a high-density recording.

The present invention solves the above-mentioned problems, and its purpose is to obtain a vertical magnetic recording medium having a laminated backing layer in which the crystal orientation of CoCr is not extremely inferior to the backing layer consisting a soft magnetic monolayer.

(Means to solve the problems)

In the vertical magnetic recording medium of the present invention, at least one set of a lower soft magnetic layer and a nonmagnetic layer is laminated on a nonmagnetic substrate, and a backing layer is formed by laminating an upper soft magnetic layer on it. Furthermore, a CoCr vertical recording layer is formed on said layer. The upper soft magnetic layer close to the above-mentioned CoCr vertical recording layer is contacted with the CoCr vertical recording layer, so that said upper soft magnetic layer is thicker than the other lower soft magnetic layer.

(Operation)

In the present invention, since the backing layer consists of at least one set of a lower soft magnetic layer and a nonmagnetic layer and one upper soft magnetic layer, the upper

soft magnetic layer nearest to the CoCr vertical recording layer is contacted with the CoCr vertical recording layer, and the thickness is thicker than the other lower soft magnetic layer, the output in the recording characteristics and the recording density characteristics can be improved without deteriorating the crystal orientation of CoCr on the backing layer.

(Application examples)

Next, an application example of the present invention is explained by the figures.

Figure 1 shows a cross section structure of the vertical recording medium which is an application example of the present invention. In the figure, 1 is a nonmagnetic substrate, 32 is a lower soft magnetic layer formed on said nonmagnetic substrate 1, 4 is a nonmagnetic layer formed on it, and 31 is an upper soft magnetic layer which is formed on said nonmagnetic layer 4 and has a thickness thicker than the above-mentioned lower soft magnetic layer 32. These soft magnetic layers 32 and 31 and the nonmagnetic layer 4 constitute a backing layer 2. Also, 5 is a vertical recording layer formed on the above-mentioned upper soft magnetic layer 31.

Next, its manufacturing method is explained.

The lower soft magnetic layer 32 is formed on the nonmagnetic substrate 1 by a well-known sputtering technique, and the nonmagnetic layer 4 is formed on it by the well-known sputtering technique. Furthermore, the upper soft magnetic layer 31 thicker than the above-mentioned lower soft magnetic layer 32

is formed on it by the well-known sputtering technique (also, for the sputtering technique, for example, see "Basic of Plasma and Film Formation," Mitsuharu Ozawa, The Nikkan Kogyo Shimbun Ltd. (1986), pp.125-138).

Next, the manufacturing method is explained in detail.

Detailed Example 1

As the nonmagnetic substrate 1, an aluminum substrate of which the surface was treated with alumite by an anodic oxidation /3 was used, and a sputtered film using a target of 78 wt% Ni and 22 wt% Fe was installed at 0.1 μm as the lower soft magnetic layer 32 on it. At that time, as sputtering conditions, an input power of 1 w/cm^2 in an Ar gas atmosphere at 3 m torr was adopted.

Next, a sputtered film using an oxide target such as SiO_2 was installed at 0.01 μm as the nonmagnetic layer 4 on it. At that time, as sputtering conditions, an input power of 1.5 w/cm^2 in an Ar gas atmosphere at 5 m torr was adopted.

Furthermore, a sputtered film using a target of 80 wt% Ni-20 wt% Fe was installed at 0.4 μm as the upper soft magnetic layer 31 on it. At that time, as sputtering conditions, an input power of 1 w/cm^2 in an Ar gas atmosphere at 3 m torr was adopted. Furthermore, a sputtered film using a target of 80 wt% Co-20 wt% Cr was installed at 0.15 μm as the vertical recording layer 5 on it.

Detailed Example 2

This example is similar to the above-mentioned Detailed Example 1 except for using a MoCu permalloy (3 wt% Mo, 5 wt% Cu,

20 wt% Fe, and 72 wt% Ni) instead of 78 wt% Ni-22 wt% Fe as the target of the above-mentioned upper and lower soft magnetic layers 32 and 31.

Detailed Example 3

This example is similar to the above-mentioned Detailed Example 1 except for using CoZrNb (85 wt% Co, 10 wt% Zr, and 5 wt% Nb) instead of 78 wt% Ni-22 wt% Fe as the target of the above-mentioned soft magnetic layers 31 and 32.

Detailed Example 4

This example is similar to the above-mentioned Detailed Example 1 except for using an oxide of Ni and Fe as the nonmagnetic layer 4. However, in the formation of the nonmagnetic layer, the same material elements (here, 78 wt% Ni-22 wt% Fe) as that used in the formation of the soft magnetic layers were used as the target, and an input power of 1.5 w/cm^2 in an O_2 gas atmosphere at 10 m torr was adopted. In other words, the nonmagnetic layer 4 was constituted from the oxide with the composition of the above-mentioned soft magnetic layers.

Detailed Example 5

This example is similar to the above-mentioned Detailed Example 4 except for using a MoCu permalloy instead of 78 wt% Ni-22 wt% Fe as the target of the above-mentioned soft magnetic layers.

Detailed Example 6

This example is similar to the above-mentioned Detailed Example 4 except for using CoZrNb instead of 78 wt% Ni-22 wt% Fe

as the target of the above-mentioned soft magnetic layers.

Next, Detailed Examples 1-6 of the prior art are explained to compare with Detailed Examples 1-6 of the above-mentioned this application example.

Comparative Example 1

As the nonmagnetic substrate, an aluminum substrate of which the surface was treated with alumite by an anodic oxidation was used, and a sputtered film using a target of 78 wt% Ni-22 wt% Fe was installed at 0.5 μm as a soft magnetic layer on it. At that time, as sputtering conditions, an input power of 1 w/cm^2 in an Ar gas atmosphere at 3 m torr was adopted. Furthermore, a sputtered film using a target of 80 wt% Co-20 wt% Cr was installed at 0.15 μm as a vertical recording layer on it.

Comparative Example 2

This example is similar to the above-mentioned Comparative Example 1 except for using a MoCu permalloy instead of 78 wt% Ni-22 wt% Fe as the target of the above-mentioned soft magnetic layer.

Comparative Example 3

This example is similar to the above-mentioned Comparative Example 1 except for using CoZrNb instead of 78 wt% Ni-22 wt% Fe as the target of the above-mentioned soft magnetic layer.

Comparative Example 4

This example is similar to the above-mentioned Detailed Example 1 except for setting the thickness of the above-mentioned upper and lower soft magnetic layers to 0.25 μm, respectively.

Comparative Example 5

This example is similar to the above-mentioned Comparative Example 4 except for using a MoCu permalloy instead of 78 wt% Ni-22 wt% Fe as the target of the above-mentioned soft magnetic layer.

Comparative Example 6

This example is similar to the above-mentioned Comparative Example 4 except for using CoZrNb instead of 78 wt% Ni-22 wt% Fe as the target of the above-mentioned soft magnetic layer.

The two-layer film media of the above comparative examples and detailed examples were recorded and reproduced by a well-known auxiliary magnetic pole excitation type vertical head (see the above-mentioned "Development Trend of Each Company for Practicality of Vertical Magnetic Recording"). The results were /4
summarized in the table of Figure 3. In the table, "D_{50}" as an estimate of the recording density is described in the above-mentioned "Development Trend of Each Company for Practicality of Vertical Magnetic Recording."

From the table, the following are understood.

(i) In the comparison of Comparative Examples 1-3 and Comparative Examples 4-6, the lamination of the backing layer improves the reproducing output, however the crystal orientation of the CoCr vertical recording layer being installed on said backing layer is deteriorated, so that the recording density is lowered.

(ii) In the comparison of Detailed Examples 1-6 and

Comparative Examples 1-6, the backing layer of the present invention improves the reproducing output and improves the recording density.

The reason for this is considered that if the total thickness of the soft magnetic layers constituting the backing layer is the same, the permeability of the multilayer of the soft magnetic layer is greater than that of the soft magnetic layer of the monolayer and the value is not considerably lowered even in a high band. In the case (i), the degradation of the crystal orientation ($\Delta\theta_{50}$) of CoCr is large, the improvement of the permeability in a high band does not appear, and the recording density is deteriorated. On the contrary, in the case (ii) of the present invention, since the degradation of $\Delta\theta_{50}$ of CoCr seldom exists, the improvement of the backing layer leads to the improvement of the recording density.

As mentioned above, in this application example, the backing layer 2 is constituted by the lower soft magnetic layer 32, nonmagnetic layer 4, and upper soft magnetic layer 31, the upper soft magnetic layer 31 is contacted with the CoCr vertical recording layer 5 on it, and the thickness of said upper soft magnetic layer 31 is thicker than the lower soft magnetic layer 32, the output in the recording characteristics and the recording density characteristics can be improved without deteriorating the crystal orientation of the CoCr vertical recording layer 5 on the backing layer 2.

Also, the present invention is not limited to the above-

mentioned application example. As the nonmagnetic layer, metals such as Cr and Ti may also be used, and as the substrate, a flexible high-molecular material may also be used.

Also, in the above-mentioned application example, the case where the nonmagnetic layer and the lower soft magnetic layer of the backing layer are respectively one layer has been shown, however as these layers, several sets may also be installed between the nonmagnetic substrate and the upper soft magnetic layer. In this case, the permeability can be much more improved.

(Effects of the invention)

As mentioned above, according to the vertical magnetic recording medium of the present invention, the backing layer of the two-layer film medium consists of at least one set of the lower soft magnetic layer and the nonmagnetic layer and one upper soft magnetic layer, and the thickness of the upper soft magnetic layer in contact with the CoCr vertical recording layer on it is thicker than the other lower soft magnetic layer constituting the above-mentioned backing layer. Thus, the output is increased, and the recording density can be improved.

4. Brief description of the figures

Figure 1 shows a cross section structure of the vertical magnetic recording medium which is an application example of the present invention. Figure 2 shows a cross section structure of a conventional vertical magnetic recording medium. Figure 3 is a table showing experimental result data of the vertical magnetic

recording medium of the application example of the present invention.

1 Nonmagnetic substrate

2 Backing layer

31 Upper soft magnetic layer

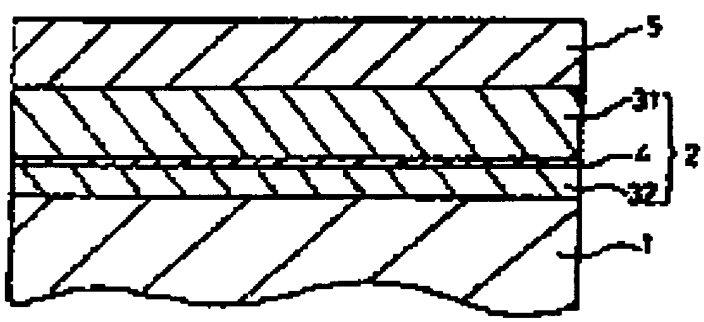
32 Lower soft magnetic layer

4 Nonmagnetic layer

5 Vertical recording layer

Also, the same symbol in the figure shows the same or corresponding part.

Figure 1:



1 Nonmagnetic substrate

2 Backing layer

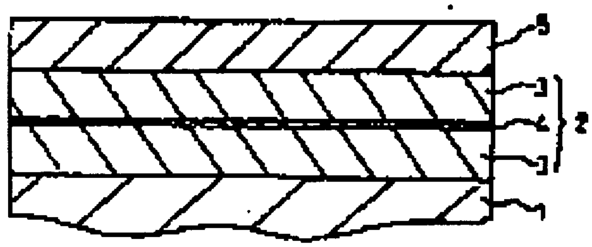
31 Upper soft magnetic layer

32 Lower soft magnetic layer

4 Nonmagnetic layer

5 Vertical recording layer

Figure 2:



3 Soft magnetic layer

Figure 3:

1. Medium
2. Constitution
3. Soft magnetic layer close to the substrate
4. Nonmagnetic layer
5. Soft magnetic layer close to CoCr
6. Reproducing output
7. Detailed Example 1

8. Comparative Example 1

9. MoCr permalloy

10. MoCu permalloy

11. MoCu permalloy

12. NiFe oxide

13. MoCu permalloy oxide

14 CoZrNb oxide

15. MoCr permalloy

16. MoCu permalloy

17. MoCu permalloy

18. MoCu permalloy

第 3 表

試料		構成			CoCr の Δθ50 (deg)	再生出力 (5kFCI)	C/N (kFCI)
		[illegible]	[illegible]	CoCr系[illegible]			
実施例	1	NiFe 2.0 μm	[illegible] 0.05μm	[illegible] 0.4μm	7.9	+2 dB	50
	2	MoCr パーマロイ 〃	〃	MoCr パーマロイ 〃	8.7	+3	53
	3	CoZrNb 〃	〃	CoZrNb 〃	8.1	+3	45
	4	NiFe 〃	NiFe の酸化物 0.01μm	NiFe 〃	7.8	-2	50
	5	MoCu パーマロイ 〃	[illegible] 〃	MoCu パーマロイ 〃	8.3	-3	55
	6	CoZrNb 〃	[illegible] 〃	CoZrNb 〃	8.4	+2	45
比較例	1	—	—	NiFe 0.3μm	7.3	0	40
	2	—	—	MoCu パーマロイ 〃	8.0	+1	40
	3	—	—	CoZrNb 〃	8.2	+2	35
	4	NiFe 0.05μm	SiO2 0.01μm	NiFe 0.25μm	16.6	-3	30
	5	MoCu パーマロイ 〃	〃	MoCu パーマロイ 〃	12.0	-3	30
	6	CoZrNb 〃	〃	CoZrNb 〃	15.9	+6	25